violent one has continued to rage among physicists. Is the electricity of the galvanic cell due to chemical action or to contact of dissimilar substances? It is to the history of the attempts to answer this question that the address is devoted.

PROGRESS OF MECHANICAL SCIENCE.

THE recent enlargement of the scope of this section to include all branches of engineering, and the increasing interest manifested in its meetings, warrant my making some remarks as to the true objects of the section, and the means of increasing its usefulness in the future.

In marked contrast with the past, the present age is one of pronounced material development. Formerly the brightest and most gifted men devoted themselves to religion, philosophy, politics, exploration, art; but for the past hundred years the attention of the leading men of the civilized world has been directed to increasing and cheapening those products which minister to the daily life and comfort of man. Farmers, mechanics, and laborers live now more comfortably than did the middle classes of feudal times; the duration of human life has been materially lengthened, and all portions of society recognize the importance of further progress, and the advantage of organization and invention in securing it.

This era of material progress may be said to have commenced with the final perfecting of the steam-engine, which, together with the various attendant machines, takes the place of hand and animal labor, and which has increased and cheapened the production of the necessaries and luxuries of life; and it has pushed the inventor and the engineer to the front rank in modern society. It may be useful to point out the absolute necessity of verbal and written intercourse between investigators and inventors, that the speculation and curiosity of the former may ripen into the effective invention of the latter. Nothing is more remarkable than the multitude of minds and facts which are required for the perfecting of even a simple machine, nor how little the last man may need to add to complete the invention. Facts and natural laws, known for years as curiosities, are taken up by some inventor, who fails in the attempt to render them of practical use; then a second genius lays hold, and, profiting by the mistakes of the first, produces, at great cost, a working machine. Then comes the successful man, who works out the final practical design, and, whether making or losing a fortune, he yet permanently benefits mankind.

The faculties of invention and discovery are generally separate. One set of men observe facts, and deduce laws therefrom; and another set endeavor to turn the results of this observation and deduction to practical account in the production of labor-saving appliances. This section should be the place where these men may meet one another, and profit by the interchange of ideas. Many of the men whom I see before me are devoting their lives to the study of nature, with no desire to make money out of it, but simply to increase human knowledge; and some of their discoveries will eventually be put into practical shapes for the use and convenience of man. History proves, too, that the scientific observers have the safer and happier part. Their success may not be so dazzling as that of some great inventors, but they do not have to bear such bitter trials and disappointments. To deduce natural laws requires mental accuracy in observing and reasoning; to make them useful in doing the world's work requires imagination and ingenuity. Sometimes long years must pass, and generation after generation of inventors wear their lives out, before a needed machine becomes an accomplished success. Evidently, then, the greater the number of minds that can be brought to bear upon a particular problem, the greater is the chance of early success. I believe that it is the particular province of this section of the association to bring these two classes of minds together, and to promote their intercourse, that the discoverer may learn in what direction fresh information is needed, and that the inventor may be advised as to what is already known.

The well-worn history of the steam-engine gives us an instance of an invention which did not spring full-grown from the brain of the inventor. History informs us that it commenced to exist two thousand years ago, in the eolipile of Hero of Alexandria. His treatise remained hidden until translated and printed in 1547; and then Branca, the Italian architect, constructed one for pounding drugs. Hero's book ran through eight editions in different languages, and attracted the attention of a French inventor, who tried vainly to raise water by steam pressure. Then came the Marquis of Worcester, who died a disappointed man after spending $250,000. Then de Morland tried using steam in cylinders, instead of in contact with the water; Papin built a steamboat, only to have it seized and destroyed while on its way to England, and he, too, died broken-hearted and poor; Savery went back to using the steam directly in contact with water; and finally Newcomen

Abstract of an address before the section of mechanical science of the American association for the advancement of science at Buffalo, Aug. 19, 1886, by O. Chanute, Esq., Kansas City, vice-president of the section.

built an engine that worked; and between 1705 and 1758 quite a number were erected. These engines had a duty of only 5,500,000 foot-pounds per pound of coal, the improvements of James Watt, an instrument maker, increasing the duty to 60,000,000.

My object in giving this sketch is to call your attention, first, to the gradual evolution of an invention by the process of exclusion, by finding out what would not do; and second, the apparent chain of connection, running for over a century, through several generations of inventors, each evidently profiting by the failures of his predecessors, to the extent, at least, of avoiding their repetition. Is it not evident that the earlier inventors would have accomplished greater results had they had a larger range of scientific experiments and advice; and that Watt triumphed because he had the whole faculty of the University of Glasgow at his back, to give him knowledge of natural principles, and information as to what had been done? So with other inventions; the steamboat was being developed from 1760 to 1807; the locomotive, from 1802 to 1829; the telegraph from 1729 to 1844; the sewing machine, with its two thousand patents, from 1790 to 1860; the reaping machine, for seventy-five years, and so on, — the last successful man adding generally but little to what had been done before. The rule is, that "the basis of success lay in a thorough acquaintance with what had been done before, and in setting about improvement in a thoroughly scientific way."

My own observation has acquainted me with the development of the ice-making machine. The economical production of cold by the combustion of fuel was a matter of theory when, in 1755, Professor Cullen experimented in Glasgow with 'quick-lime and spirits of sal-ammoniac' as the best volatile substance for producing cold. His discoveries remained as laboratory experiments until Jacob Perkins, in 1834, obtained a partial success in producing ice by the evaporation of ether. Then came Professor Twining, of New Haven, Leslie, Valance, Harrison, Pontifex Seibe, Windhausen, Tellier, Carré, and Pictet, with more or less doubtful success. Up to 1869, the machine was in the experimental or unsuccessful stage. Then came an experimenter who deliberately read up the whole subject in a library, and made himself master of what patent-attorneys call 'the state of the art,' and of the scientific principles concerned, working, according to his own account, 'harder than he ever had before in his life.' He discarded the usual working fluids, and adopted anhydrous ammonia. After various struggles and successes, the machine was adapted to the difficulties of the case, and put in successful operation in 1874, since which time it has become of immense practical importance in warm climates, for making ice, cooling breweries, etc., though giving an efficiency of but seventy per cent. In 1877, another inventor set himself deliberately to improve the machine. He put a practical mechanic, a chemist, and a patent-attorney to work, and in 1878 built a machine, which, however, gave no improved results. He did not let the matter rest here, however, but persevered, and in 1880 built an entirely successful machine, which did the work for which seven thousand tons of ice had been required. So rapid has been the introduction of refrigerating machines, that there are now several hundred of various makes at work in the United States. They produce as much cold for each ton of coal consumed as would be obtained by the melting of twenty tons of ice, at which rate natural ice is worth only seventy-five to eighty cents per ton, or less than the usual cost of harvesting and storing it.

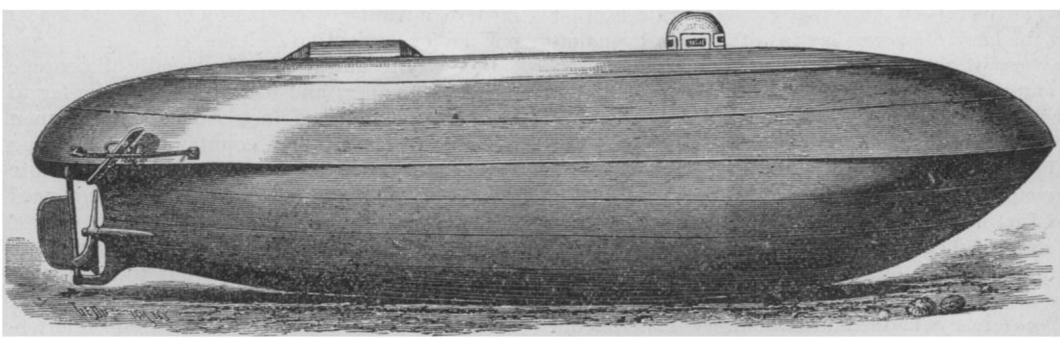
In comparing this development with that of the steam-engine, we see the difference between the scientific way of working out an invention and the former disjointed way, when each man had to rely chiefly upon his own experiments; and also the difference between ancient facilities and the modern advantages offered by experts, technical publications, scientific societies, etc.

Ordinary technical societies usually discourage speculative papers and discussions, and prefer to hear of accomplished facts; but the busy men who are developing this country need something more,— they need to keep up with discovery before it is reduced to practical account, and they need that personal contact and sympathy with men of science which nothing can replace. Engineers, as well as other practical men, owe it to themselves to come to these meetings, bringing accounts of what they have done and hope to do, and especially of what they have failed to do, and why; and some speculative papers may well be allowed providing always that they are on a sound basis, and stick to facts; for how often is it that the imagined things of to-day become the accomplished results of to-morrow!

To encourage good work in the preparation of papers, might there not be established, by friends of the association and section, prizes for the best papers on a number of important subjects? I hope to see something done in this direction before the close of the meeting. I hope also to see the practice inaugurated for members, during the year or meeting, to propound queries upon subjects about which they wish information or discussion. I should like also to see published annu-

ally lists of subjects upon which papers are desired by the section, as was done to some extent in the recent circulars of the section. In this way, live subjects are apt to be most beneficially canvassed, and experiment and discovery kept in the right paths. It may be well, in this connection, to mention some inventions which are now, so to speak, 'in the air;' of course, we all recognize that the flying-machine belongs to this class, in one sense if not in another, and a paper upon it has been presented which may prove of interest to you. What is needed, however, is a sufficiently light motor, without which a flying-machine cannot be expected to succeed. Steam power, also, for agricultural work in its many forms, is not yet an accomplished fact; and we may mention one machine greatly needed, — a cotton-picker. Then, too, there is the electric motor for street traffic, which needs further improvement; also the transmission of power over great distances, electric lighting, etc., etc.

But I have said enough to indicate how large a field may, in my judgment, be covered by this section of mechanical science and engineering, and how its meetings may in the future be made still more useful and interesting than they have been in the past.



TUCK'S SUBMARINE TORPEDO BOAT.

A NEW SUBMARINE TORPEDO BOAT.

THE accompanying illustration represents a new submarine boat, invented by Mr. J. H. L. Tuck, and now being tested in this city, with highly satisfactory results. On Tuesday, August 24, the first public exhibition of the vessel was given in the Hudson River, opposite 86th street, in the presence of a number of scientific men. Manned by a crew of two men, pilot and engineer, she started off at a good rate of speed, disappeared, travelled perhaps half a mile without making a ripple to indicate her whereabouts, and reappeared at the pleasure of the pilot. During the two hours' test, she travelled several miles, answering her helm as readily as a steam yacht. The boat is an iron spindle thirty feet long by eight in diameter, with a propeller, and vertical and horizontal rudders. The motive power is a fourteen horse-power Westinghouse engine, furnished with steam from a caustic-potash reservoir, which is charged from an outside source. Deadlights in the conning-dome forward, together with a compass, enable the pilot to shape his course. Ingress and egress are effected through an aperture in the hatchway near the stern, which may be hermetically sealed from the inside.

NOTES AND NEWS.

THE officers for the next meeting of the American association are as follows: President, S. P. Langley. Vice-presidents: mathematics and astronomy. Wm. Ferrel; physics, Wm. A. Anthony; chemistry, Albert B. Prescott; mechanical science and engineering, Eckley B. Coxe; geology and geography, G. K. Gilbert; biology, W. G. Farlow; anthropology, D. G. Brinton; economic science and statistics, Henry E. Alvord. Permanent secretary, F. W. Putnam; general secretary, W. H. Pettee; assistant general secretary, J. C. Arthur. Secretaries of the sections: mathematics and astronomy, Henry M. Paul; physics, C. Leo Mees; chemistry, C. F. Mabery; mechanical science and engineering, Geo. M. Bond; geology and geography, T. B. Comstock; biology, J. Henry Comstock; anthropology, F. W. Langdon; economic science and statistics, Wm. R. Lazenby. Treasurer, William Lilly.

— Twenty drops of bromine in an ounce of olive-oil, applied freely four times a day, and the affected part washed with warm water and castile soap twice a day, is said to have completely cured seventy-five cases of ivy poisoning.